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Smart Wall Box Switch with Dynamic Configurable Buttons

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Abstract

A configurable smart wall box switch system is designed, comprising a modular interface capable of supporting from one (1) to eight (8) user-actuatable buttons within a single gang switch housing. Each button on the smart switch can be configured independently and dynamically assigned to different functions. The system includes a microcontroller-based control unit(s), supporting single or multiple communication protocols, a Near Field Communication (NFC) interface, and a user interface for assigning and modifying button functions. The smart switch, either AC or DC powered, allows physical reconfiguration of buttons without electrical rewiring.

Detailed Description

A **configurable smart wall box switch** system is designed to provide flexible control over electrical devices and smart home functions. The system comprises a modular interface capable of supporting from one (1) to eight (8) user-actuatable buttons. Each button on the smart switch is independently reconfigurable and can be dynamically assigned to different functions, such as lighting, fan control, scene activation, or integration with smart home ecosystems like Bluetooth, Zigbee, Z-Wave, Wi-Fi-based or wired LumaCAN platforms.

The system includes a microcontroller-based control unit(s), supporting single or multiple communication protocols, a Near Field Communication (NFC) interface for local configuration, user authentication, or device pairing, and a user interface for assigning and modifying button functions. Examples of communication protocols include a personal area network (Bluetooth, a trademark of Bluetooth SIG, Inc), a Zigbee network (a trademark of the Connectivity Standards Alliance), a low-power mesh network (e.g., Z-Wave, a trademark of by Z-Wave Alliance, Inc), an

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IEEE 802.11 communication network (e.g., Wi-Fi®, a trademark of the Wi-Fi Alliance), an application protocol on a Control Area Network (e.g., LumaCAN, a trademark of Leviton Manufacturing Co., Inc.). The smart switch housing is designed to accommodate interchangeable button modules, allowing physical reconfiguration without electrical rewiring from one (1) button to eight (8) buttons. The smart switch can have different power configurations by using either AC or DC power. The smart wall box switch may be accompanied by a mobile application which can be used to auto-configure the software for buttons and visual or haptic feedback mechanisms based on the image of the button configuration taken using the mobile application.

Referring to the mechanical design figures below, the smart switch that can fit in a standard single gang box. The buttons of all sizes are independent of direction and can be mounted on the button frame both ways in the vertical direction. Also, button frame can be mounted in any vertical direction on the rack providing more flexibility to the user. The mechanicals have been designed to use only two (2) screws instead of traditional four (4) screws helping in carbon reduction.

Technical Advantages

1. **Modular Button Configuration (1–8 Buttons)**
    - Enables flexible deployment in various room types and control scenarios.
    - Reduces the need for multiple switch models.
2. **Software-Based Reconfiguration**
    - Allows users to assign or change button functions as needed
    - Supports dynamic updates via mobile app or web interface.
3. **NFC Interface Integration**
    - Enables secure, contactless configuration and user authentication.
    - It facilitates quick pairing with mobile devices or smart home hubs without Wi-Fi.
4. **Multi-Protocol Communication Support**
    - Compatible with Wi-Fi, Zigbee, Bluetooth, and other smart home standards.
    - Enhances interoperability with existing ecosystems.
5. **Tool-Free Physical Reconfiguration**
    - Button modules can be added or removed without rewiring or specialized tools.
    - Simplifies installation and maintenance.
6. **Feedback Mechanisms**
    - LED or haptic feedback improves user interaction and accessibility.
7. **Over-the-Air (OTA) Updates**
    - Ensures long-term support and feature expansion without physical access.

System Components

Switch Housing

The switch housing is designed to accommodate up to eight button modules. It includes:

- A mounting frame compatible with standard electrical boxes.
- A backplane with physical tactile buttons for each button slot.
- A locking or snap-fit mechanism for secure and tool-free installation of button modules.

Button Modules

Each button module is:

- Electrically and mechanically independent.
- Interchangeable and hot-swappable.
- Capable of supporting mechanical actuation.
- Optionally equipped with LEDs, haptic actuators, or tactile indicators.

Control Unit

The control unit includes:

- A microcontroller or embedded processor (s).
- Memory for storing configuration profiles.
- A power management circuit.
- Interfaces for wireless communication (e.g., Wi-Fi, Zigbee, Bluetooth).
- An NFC interface for local configuration and secure access.

NFC Interface

The NFC interface enables:

- Local configuration via a smartphone or NFC-enabled device.
- Secure pairing and authentication.
- Profile import/export and cloning.
- Offline configuration without requiring internet access.

Software Interface

The configuration software (mobile or web-based) allows users to:

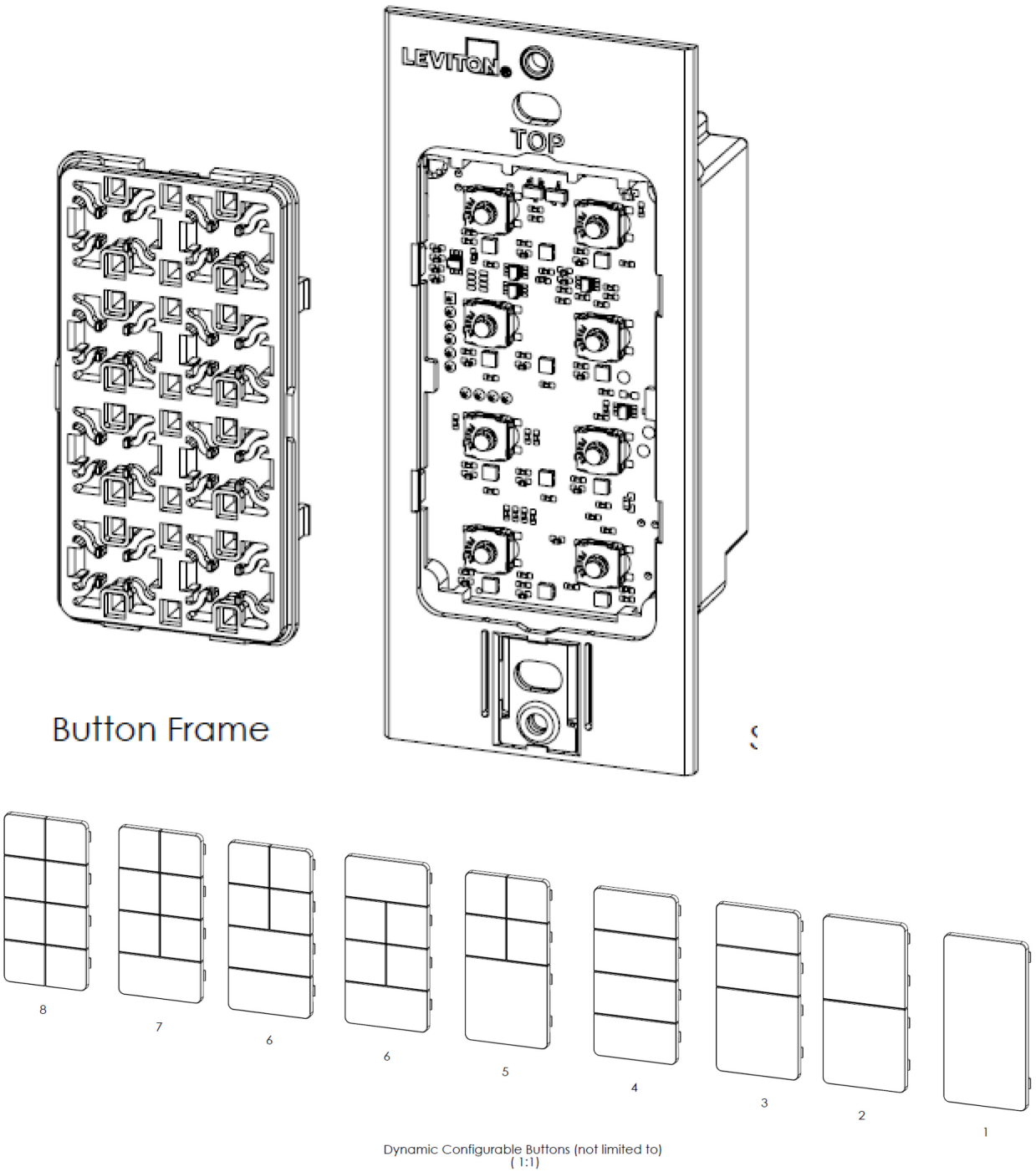
- Assign functions to each button (e.g., lighting, scenes, appliances).
- Define multi-function inputs (e.g., single press, double press, long press).
- Preview and simulate button behavior.
- Manage user roles and access permissions.
- Perform over-the-air (OTA) updates.

Use Cases

1. **Residential Smart Home Control**
    - Control lights, fans, blinds, or scenes from a single customizable switch.
2. **Commercial Building Automation**
    - Configure different button layouts for conference rooms, lobbies, or offices.
3. **Hospitality Industry**
    - Allow hotel staff to reconfigure room controls based on guest preferences.
4. **Accessibility Applications**
    - Customize button size and function for users with mobility or vision impairments.
5. **Temporary or Event-Based Installations**
    - Reconfigure buttons for events, exhibitions, or seasonal lighting setups.
6. **Multi-User Environments**
    - Use NFC to load personalized control profiles for different users (e.g., in co-working spaces or shared apartments).

Modular Button Configuration (1–8 Buttons)

Mechanical design



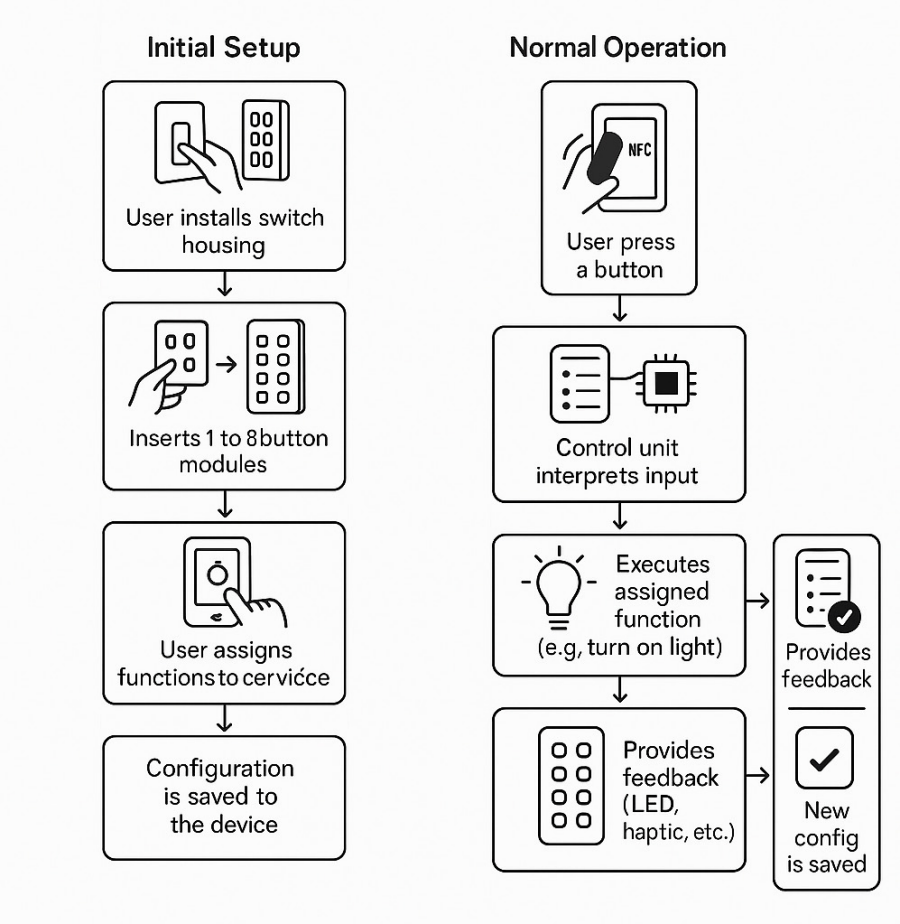
Flowchart of user configurating the buttons

Button Configuration Process Flowchart
User opens the app
User scans the QR code on product which opens the switch configuration - new / modify
User captures the photo of the front of the product
App scans the butttons configuration from the photo
Image scan error
App successfully scans the image and recognize button configuration
User confirms the button configuration pattern
User marks pattern incorrect
App saves pattern to history
App send pattern to product
Product reconfigures button & visual feedback as per the pattern
User confirms the visual feedback pattern
Process complete.

Visual representation illustrating user interaction with a configurable smart wall switch system

The flowcharts should include the following processes:

1. **Initial Setup**: - User installs the switch housing - Inserts 1 to 8 button modules - Powers on the device.
2. **NFC-Based Configuration**: - User taps smartphone to NFC interface - App launches configuration mode - User assigns functions to each button - Configuration is saved to the device.
3. **Normal Operation**: - User presses a button - Control unit interprets input - Executes assigned function (e.g., turn on light) - Provides feedback (LED, haptic, etc.).
4. **Reconfiguration**: - User taps NFC again - App loads current config - User modifies button functions - New config is saved.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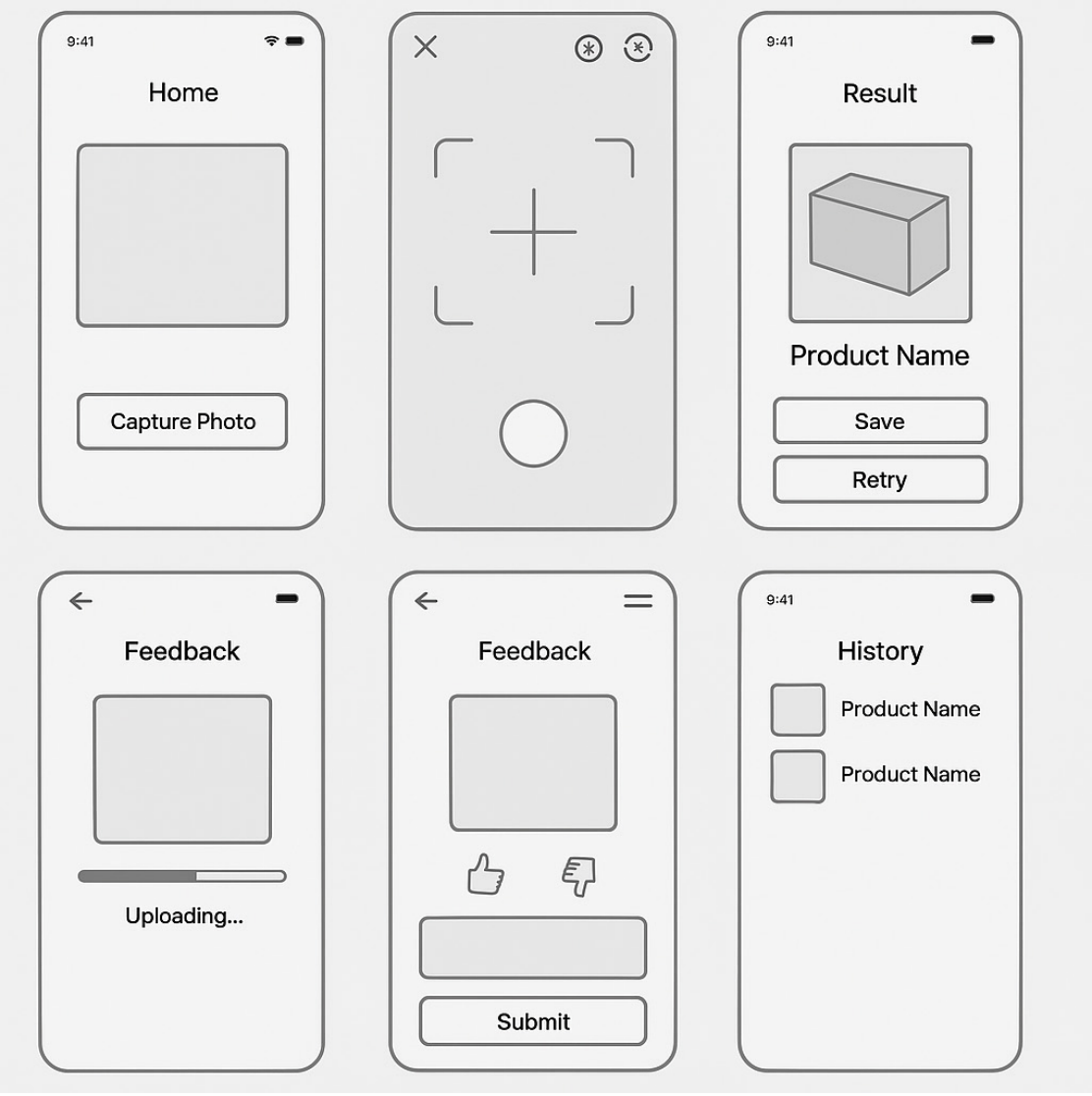
User installs switch housing
Inserts 1 to 8 button modules
User assigns functions to cervicce
Configuration is saved to the device
Normal Operation
NFC
User press a button
Control unit interprets input
Executes assigned function (e.g, turn on light)
Provides feedback (LED, haptic, etc.)
Provides feedback
New config is saved

User Interface Wireframe

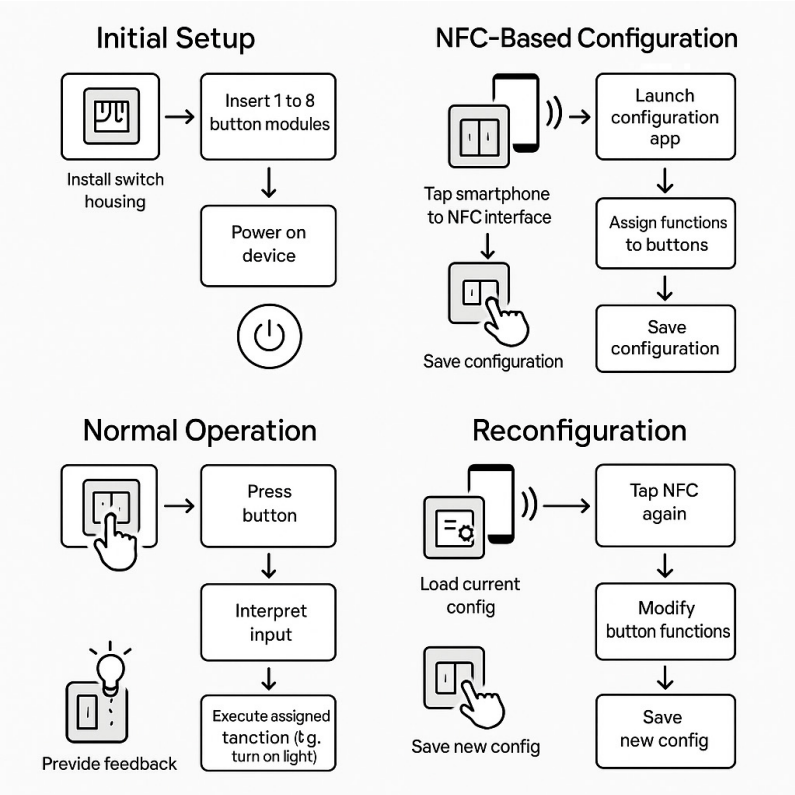
A user interface (UI) wireframe for a mobile app that allows a user to take a photo of a product and get it recognized. The wireframe should include the following screens:

1. Home screen with a button to capture a photo.
2. Camera interface for taking a photo.
3. Uploading screen with a progress indicator.
4. Recognition result screen showing the product name, image, and options to save or retry.
5. Feedback screen with thumbs up/down and a text box.



Graphical version of flowcharts for a configurable smart wall switch system

1. **Initial Setup:** - Install switch housing - Insert 1 to 8 button modules - Power on device
2. **NFC-Based Configuration**: - Tap smartphone to NFC interface - Launch configuration app - Assign functions to buttons - Save configuration
3. **Normal Operation**: - Press button - Interpret input - Execute assigned function (e.g., turn on light) - Provide feedback (LED, haptic)
4. **Reconfiguration**: - Tap NFC again - Load current config - Modify button functions - Save new config Use clean, modern design with icons for actions like tapping, pressing, configuring, and feedback. Each flowchart should be visually distinct but stylistically consistent.
5. **Firmware Update via NFC**: - User taps smartphone to switch - App checks for firmware update - Downloads and transfers update - Switch reboots and applies update
6. **User Profile Switching**: - User taps NFC tag or phone - Switch detects user identity - Loads personalized button configuration - Applies user-specific settings
7. **Error Handling & Diagnostics**: - System detects malfunction - Logs error internally - User taps phone to retrieve logs - App displays diagnostics and suggestions
8. **Factory Reset**: - User holds specific button combo - Confirmation prompt via LED or app - User confirms via NFC - System erases config and reboots Design should match the previous flowcharts: clean, modern, with icons for actions like tapping, downloading, confirming, and rebooting. Each flowchart should be visually distinct but stylistically consistent.


Initial Setup
Install switch housing
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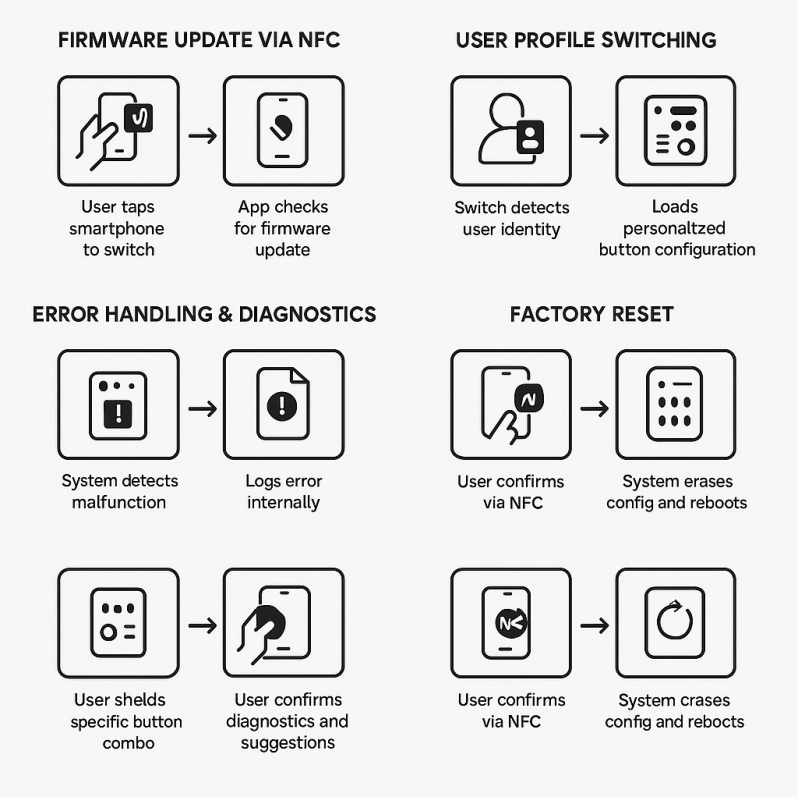
FIRMWARE UPDATE VIA NFC
User taps smartphone to switch
App checks for firmware update
USER PROFILE SWITCHING
Switch detects user identity
Loads personaltzed button configuration
ERROR HANDLING & DIAGNOSTICS
System detects malfunction
Logs error internally
User shelds specific button combo
User confirms diagnostics and suggestions
FACTORY RESET
User confirms via NFC
System erases config and reboots
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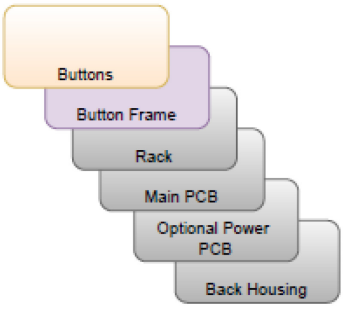
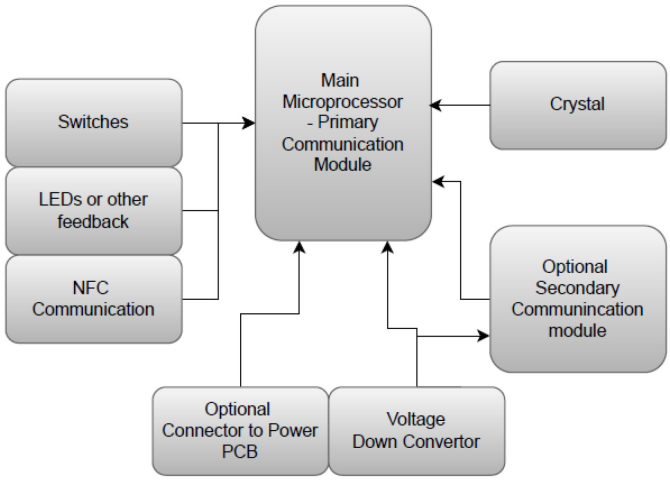
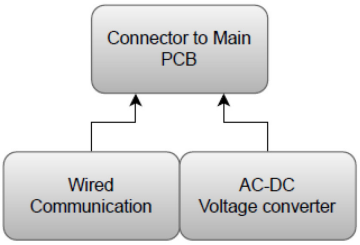
Block Diagram



Exploded View of Internal Components



Main PCB Components



Power PCB Components

Features

A configurable smart wall switch system comprising:

- a switch housing configured to accommodate between one (1) to eight (8) user-actuatable button modules.
- a microcontroller-based control unit operatively coupled to the button modules.
- a wireless communication module selected from the group consisting of Wi-Fi, Zigbee, Bluetooth or other wired/ wireless communication protocol.
- a Near Field Communication (NFC) interface configured to enable local configuration, user authentication, or device pairing.
- a software interface for assigning and modifying the function of each button module independently.
- wherein the button modules are physically interchangeable and user-configurable within the housing without requiring electrical rewiring.

The button modules can be either capacitive touch or mechanical actuation mechanisms, or a combination of the two.

One or more of the button modules may provide visual or haptic feedback.

The NFC interface may be configured to initiate secure pairing with a mobile device for configuration without requiring internet connectivity.

Each button module may be associated with a unique identifier stored in non-volatile memory to retain configuration during module replacement.

The button modules may be hot-swappable, allowing replacement or reconfiguration while the system remains powered.

The housing may include a magnetic or snap-fit mechanism to facilitate tool-free installation and removal of button modules.

The system may use a mobile application to communicate with the NFC interface to upload configuration profiles.

The system may be configured to integrate with third-party smart home ecosystems, such as Apple HomeKit, Google Home, or Amazon Alexa.

The control unit may be configured to log user interactions and transmit usage data to a cloud-based analytics platform.

The button modules may be designed to support multi-function input, including single press, double press, and long press actions.

The NFC interface may also be configured to read user-specific profiles stored on an NFC tag or mobile device to personalize button functions upon detection.

The button modules may include integrated RGB LEDs for status indication, user feedback, or ambient lighting.

The NFC interface may be configured to provide multilingual audio prompts during configuration to assist users with accessibility needs.

The housing may include a display or indicator panel to show the current configuration or status of each button module.

The NFC interface may be configured to operate in both read and write modes to facilitate two-way communication with external devices.

The button modules may be arranged in a grid or linear layout, and the layout detected and interpreted by the control unit for spatial mapping of functions.

The system may include a tamper detection mechanism that disables configuration changes unless authenticated via the NFC interface.

The configuration software may include a drag-and-drop interface for assigning functions to button modules based on their physical position.

The NFC interface may be configured to initiate a secure configuration mode when a predefined gesture or sequence is performed on the button modules.

The button modules may be color-coded or labeled to assist in physical identification and configuration.

The control unit may be configured to detect and respond to power quality events, such as voltage sags or surges, by adjusting button behavior or disabling non-essential functions.

The NFC interface may be configured to store a backup of the current configuration, allowing restoration in case of system reset or module replacement.

The button modules may be designed to support user-defined macros that execute a sequence of actions upon a single press.

The NFC interface may be configured to initiate a secure configuration session only when the wall switch is in a predefined physical orientation or state.

The configuration software may support user profiles, enabling different button configurations based on user identity detected via NFC.

The system may be configured to operate in both standalone and networked modes, with automatic switching based on connectivity status.

The NFC interface may be configured to trigger different configuration modes based on the type of NFC device presented, such as administrator, installer, or end-user.

The configuration software may include a cloud-based dashboard for remote monitoring and management of multiple smart wall switch units.

The control unit may be configured to synchronize button configurations across multiple wall switch units within a networked environment.

The NFC interface may be configured to log configuration changes and store a history of user interactions for audit or diagnostic purposes.

The button modules may be designed to support interchangeable icon inserts that are automatically recognized by the control unit using embedded RFID or optical markers.

The housing may include a backup power source to retain configuration and enable limited functionality during power outages.

The configuration software may include a simulation mode that allows users to preview button behavior before applying changes to the physical switch.

The system may support integration with building management systems (BMS) for centralized control and monitoring.

The NFC interface may be configured to operate in conjunction with biometric authentication on a mobile device to authorize configuration changes.

The button modules may include a tactile surface texture or shape variation to assist visually impaired users in identifying button functions.

The control unit may be configured to automatically adjust button functions based on time of day, occupancy, or environmental conditions.

The NFC interface may be used to clone configuration settings from one wall switch unit to another.

The NFC interface may be configured to support configuration based on user presence detected via wearable NFC-enabled devices.

The configuration software may include a permissions management system to restrict access to certain functions based on user roles.

The system supports firmware may rollback via NFC in the event of a failed over-the-air update.

The button modules are capable of detecting force sensitivity to differentiate between light and firm presses for multiple control actions.

The NFC interface may be configured to initiate a secure guest mode that temporarily limits button functionality based on predefined access rules.

The button modules may be designed to support modular expansion through daisy-chaining additional units.

The configuration software may include a visual layout editor that mirrors the physical arrangement of button modules for intuitive setup.

The control unit may be configured to operate in a low-power mode and wake upon NFC interaction or button press.

The NFC interface may support configuration via contactless smart cards in addition to mobile devices.

The NFC interface may be configured to provide localized configuration options based on the geographic region of the user.

The control unit may be configured to automatically detect and resolve conflicts in button assignments during configuration.

The control unit may be configured to detect and respond to emergency gestures or button sequences to trigger alerts or safety protocols.

The NFC interface may be configured to initiate a secure firmware recovery process in the event of a system failure.

The button modules may be equipped with interchangeable faceplates to allow for aesthetic customization.

The control unit may be configured to support mesh networking for communication with other smart switches in the same environment.

The NFC interface may be configured to provide real-time diagnostics and system health information to a mobile device.

The button modules may include a locking mechanism that prevents accidental reconfiguration during cleaning or maintenance.

The configuration software may include a scheduling feature that allows button functions to change based on time or calendar events.

The system may be configured to operate in a dual-mode configuration, allowing both local and cloud-based control and monitoring.

The NFC interface may be configured to support multi-device synchronization, enabling simultaneous configuration of multiple switches with a single tap.

The NFC interface may be configured to support encrypted configuration profiles to prevent unauthorized access or tampering.

The button modules may be designed to support dual-color LED indicators to reflect both status and function category.

The configuration software may include a remote diagnostics feature that allows technical support personnel to access system logs via NFC.

The button modules may be equipped with a pressure-sensitive surface to enable analog input control, such as dimming or volume adjustment.

The NFC interface may be configured to initiate a secure factory reset procedure when a specific NFC tag is presented.

The NFC interface may be configured to support configuration import/export using encrypted QR codes scanned via a companion app.

The configuration software may include a real-time preview mode that simulates button behavior before applying changes

The NFC interface may be configured to provide real-time feedback to the user during configuration, including success or error notifications.

The NFC interface may be configured to support time-limited configuration sessions that automatically expire after a predefined duration.

The button modules may be designed to emit a unique vibration pattern corresponding to their assigned function.

The configuration software may include a visual history log of all configuration changes made via the NFC interface.

The NFC interface may be configured to initiate a secure pairing process with a central hub or gateway device for network enrollment.

The button modules may be designed to support interchangeable function overlays, such as icons or labels, that are automatically recognized by the control unit.

The control unit may be configured to detect and respond to environmental noise levels by adjusting button feedback or behavior.

The NFC interface may be configured to allow configuration cloning across different models or versions of the smart wall switch.

The NFC interface may be configured to support configuration rollback to a previously saved state upon user request.

The NFC interface may be configured to support multi-user configuration sessions, allowing collaborative setup by multiple authorized devices.

The button modules may be designed to support dual-function operation, enabling both local control and remote override via network commands.

The configuration software may include a virtual assistant interface for voice-guided setup and diagnostics.

The NFC interface may be configured to initiate a secure configuration lockout after a predefined number of failed authentication attempts.

The button modules may be designed to support interchangeable actuation mechanisms, including rocker, push, and capacitive touch types.

The control unit may be is configured to detect and respond to occupancy data from external sensors to dynamically adjust button functions.

The NFC interface may be configured to provide contextual help or tutorials based on the current configuration state.

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